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The Study of the Species from Genus *Selaginella* (Selaginellaceae) in Forest of Peninsular Malaysia

Kajian Spesies dari Genus *Selaginella* (Selaginellaceae) di Hutan Semenanjung Malaysia

Nurfarahain, Zainal, Haja Maideen Kader Maideen & Shaharuddin Mohamad Ismail

ABSTRACT

An anatomical study was carry out on 14 taxa belonging to Selaginellaceae in an attempt to study their stipe anatomical characteristics and to provide anatomical data for the selected taxa in Selaginellaceae. Out of 29 taxa of Selaginellaceae recorded in Peninsular Malaysia, 14 taxa have been selected namely Selaginella alutacia, S. argentea, S. frondosa, S. intermedia var. intermedia, S. intermedia var. dolichocentrus, S. mayeri, S. morganii, S. ornata, S. plana, S. polita, S. roxburghii var. roxburghii, S. stipulata, S. wallichii and S. willdenowii. Method used in this study is sectioning using sliding microtome. Findings in this study have shown that Selaginellaceae species studied can be cluster into two groups, based on the stipe stellar systems, which are monostelic and tristelic groups. There are some variations exist in the cross sections of the stipes of the same species due to the presence and absence of the leaf trace. Each species is prove to have distinct stipe anatomical characteristics that can be used to differentiate species in Selaginellaceae.

Keywords: Stipe anatomy; Genus Selaginella; Peninsular Malaysia

ABSTRAK

Satu kajian anatomi telah dijalankan ke atas 14 sampel milik Selaginellaceae dalam usaha untuk mengkaji ciri-ciri anatomi daun mereka dan untuk menyediakan data anatomi untuk sampel yang dipilih dalam Selaginellaceae. Daripada 29 sampel Selaginellaceae dicatatkan di Semenanjung Malaysia, 14 sampel telah dipilih iaitu Selaginella Alicia, S. argentea, S. frondosa, S. intermedia var. intermedia, S. intermedia var. dolichocentrus, S. mayeri, S. morganii, S. ornata, S. plana, S. polita, S. roxburghii var. roxburghii, S. stipulata, S. Wallichii dan S. willdenowii. Kaedah yang digunakan dalam kajian ini adalah pembahagian menggunakan mikrotome gelongsor. Penemuan dalam kajian ini telah menunjukkan bahawa spesies Selaginellaceae dikaji dapat dikelompokkan ke dalam dua kumpulan, berdasarkan sistem bintang daun, yang kumpulan monostelik dan tristelik. Terdapat beberapa variasi wujud di dalam keratan rentas daripada stipes daripada spesies yang sama disebabkan oleh kehadiran dan ketiadaan kesan daun. Setiap spesies dibuktikan dengan mempunyai ciri-ciri anatomi daun yang berbeza yang boleh digunakan untuk membezakan spesies dalam Selaginellaceae.

Kata kunci: Stipe anatomi; Genus Selaginella; Semenanjung Malaysia

INTRODUCTION

The spikemoss family Selaginellaceae is an ancient group of lycopods which are sister group to a clade of all living plants (Korall et al. 1999). The Selaginellaceae is classify together with Lycopodiaceae and Isoetaceae under the phylum Lycophyta, while the remaining fern families are categorize into the phylum Monilophyta. Selaginellaceae is a monotypic heterosporous group of ferns comprising the genus *Selaginella,* which composed of an estimated 750 extant species. Most species in *Selaginella* are small and delicate and mainly occur in abundance in the tropical zones of the world (Foster & Gifford 1974). In Peninsular Malaysia, *Selaginella* is represent by 29 taxa, nine of which are endemic to the area (Parris & Latiff 1997; Wong 2010). The morphology of *Selaginella* has been study and review by Wong (1983, 2010). The identification of *Selaginella* depends much on the minute leaves that make it hard to differentiate because of the rather similar leaves morphology. Hence, the anatomical data could be useful to identify and to distinguish species in the genus. The objectives of this research are therefore to study the anatomical characteristics of the stipe of selected species of *Selaginella* in Peninsular Malaysia and to find the useful anatomical characters that can be used to help in the identification of the species. This study can help in relating anatomical study of plant or fern with urban design nowadays. It is also can help to integrate research and understanding of plants into the structure of the cities, and to make

use of the anatomical structure of plant as urban design for the green cities.

MATERIALS AND METHODS

A total of 14 taxa of *Selaginella* have been used in this study namely, *S. alutacia, S. argentea, S. frondosa, S. intermedia* var. *intermedia, S. intermedia* var. *dolichocentrus, S. mayeri, S. morganii, S. ornata, S. plana, S. polita, S. roxburghii* var. *roxburghii, S. stipulata, S. wallichii* and *S. willdenowii* (Table 1). The stipe of each species was sectioned using sliding microtome. The method used for sectioning was according to the protocol by Johansen (1940) and Sass (1958) with some suitable modifications. The slide preparations were observe under light microscope and images were analysed using Analysis Docu Software.

TABLE 1. The specimens collected for this study and their specific location listed below

SPESIES	COLLECTORS & COLLECTION NO.	LOCALITY
Selaginella alutacia	Razali Jaman, Masnoryante & Hazwani, NHA2011-09 (UKMB)	Selangor, Ulu Gombak
	Razali Jaman, Masnoryante & Hazwani, NHA2011-11, NHA2011-13 (UKMB).	Selangor, Sg. Semungkis
Selaginella argentea	Razali Jaman & Hazwani, NHA2011-29 (UKMB).	Selangor, Hutan Simpan Kekal UKM
Selaginella frondosa	Razali Jaman & Hazwani, NHA2011-30 (UKMB).	Selangor, Hutan Simpan Kekal UKM
Selaginella intermedia* var. *dolichocentrus	Razali Jaman, Masnoryante & Hazwani, NHA2011-20, NHA2011-21 (UKMB)	Selangor, Fraser's Hill, Pinetree Trail
Selaginella intermedia* var. *intermedia	Razali Jaman, Masnoryante & Hazwani, NHA2011-23 (UKMB).	Pahang, Cameron Highlands, Hutan Lipur Parit Fall
Selaginella mayeri	Razali Jaman, Masnoryante & Hazwani, NHA2011-03, NHA2011-04, NHA2011-05 NHA2011-06 (UKMB)	Selangor, Ulu Gombak
	Razali Jaman, Masnoryante & Hazwani, NHA2011-14 (UKMB).	Selangor, Sg. Semungkis
Selaginella morganii	Razali Jaman, Masnoryante & Hazwani, NHA2011-24 (UKMB).	Pahang, Cameron Highlands, Hutan Lipur Parit Fall
Selaginella ornata	Razali Jaman, Masnoryante & Hazwani, NHA2011-18, NHA2011-19 (UKMB)	Selangor**,** Fraser's Hill, Jeriau
	Razali Jaman, Masnoryante & Hazwani, NHA2011-22 (UKMB)	Pahang, Cameron Highlands, Hutan Lipur Parit Fall
Selaginella plana	Razali Jaman & Hazwani, NHA2011-31 (UKMB).	Selangor, Hutan Simpan Kekal UKM
Selaginella polita	Razali Jaman, Masnoryante & Hazwani, NHA2011-27 (UKMB).	Pahang, Cameron Highlands, Gunung Brinchang
Selaginella roxburghii* var. *roxburghii	Razali Jaman, Masnoryante & Hazwani, NHA2011-08 (UKMB)	Selangor, Ulu Gombak
	Razali Jaman, Masnoryante & Hazwani, NHA2011-12 (UKMB)	Selangor, Sg. Semungkis, Selangor, Ulu Kemensah
	Razali Jaman, Masnoryante & Hazwani, NHA2011-15, NHA2011-17 (UKMB).	
Selaginella stipulata	Razali Jaman, Masnoryante & Hazwani, NHA2011-16 (UKMB).	Selangor, Ulu Kemensah
Selaginella wallichii	Razali Jaman, Masnoryante & Hazwani, NHA2011-01 (UKMB).	Selangor,Ulu Gombak
Selaginella willdenowii	Razali Jaman, Masnoryante & Hazwani, NHA2011-02 (UKMB)	Selangor, Ulu Gombak

RESULTS AND DISCUSSION

Based on the stipe anatomical characteristics, the *Selaginella* species studied can be cluster into two groups based on the number of stele in the cross section namely; monostelic and tristelic group (Figure 1). In the monostelic group, the stipes outline is variable from circular (*S. argentea, S. intermedia* var. *dolichocentrus, S. intermedia* var. *intermedia, S. morganii, S. ornata, S. polita* and *S. roxburghii* var. *roxburghii*), to elliptical (*S. alutacia*) and tetragonal (*S. frondosa*) in shape. In the tristelic group, the stipes outline is variable from circular (S. *willdenowii*) and elliptical (*S. mayeri, S. plana, S. stipulata* and *S. wallichii*). Interspecific variations also occur in the stelar shapes, sizes and arrangements. Most species in the current study have flat or ribbon-shaped stele while in *S. mayeri* and *S. willdenowii*, both have circular and flat steel. The stele of *S. frondosa* shows a different shape where the both ends curve upwards and possess four protoxylems in the lower part of cross sections instead of two as in most of the species.

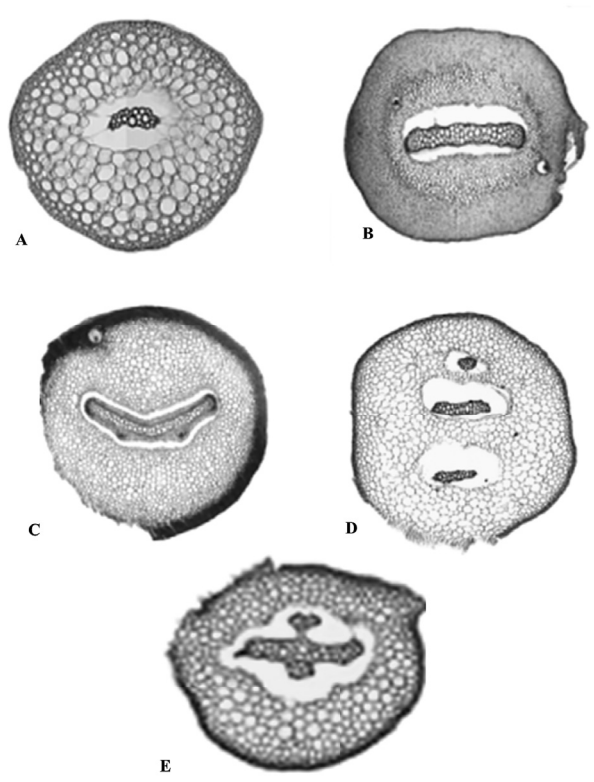

FIGURE 1. Monostelic group (A) S. argentea, (B) S. alutacia, (C) S. frondosa, and tristelic group (D) S. mayeri, (E) S. willdenowii.

The cross sections of the stipe show the presence of a large cortex. In some species, the cortex seems to be larger on the abaxial side than the adaxial side. Generally, the position of the stele in the monostelic group is at the center of the stipe or located at 1/3 from the adaxial side of the stipe. Likewise, the position of the stele in the tristelic group is also at the center of the stipe where the meristeles are arranged parallel to each other. The cortex in *Selaginella* is separate from the stele by a conspicious intercellular spaces or lacuna. Each stele in monostelic and tristelic group is enclose by the lacuna. For the tristelic group, each meristele is enclose by its very own lacuna except for *S. willdenowii* where the three meristeles shared one large lacuna.

The cross sections of the stipe of all species studied showed the epidermal layer consisting of one layer of thick walled cells. Trichome and stomata seems to be absence in all species studied. This result finding to be similar to those stated by Parihar (1965), Ogura (1972) and Bold (1973).

The cortex is composed of thin-walled, green, angular parenchymatous cells as a whole without intercellular air spaces. In most species with a rigid stipes, the cortex may be partially sclerenchymatous by forming a hypodermal sclerenchyma (Parihar 1965). According to Ogura (1972), the hypodermal layer can be found only in erect or sub-erect species and lacking in the creeping ones. However, in the current study, the hypodermal layers were also observe in the creeping stipes in *S. alutacia*. Only report the collenchyma cells were absence in Selaginellaceae species studied and are actually rare in most pteridophytes, and has in the stipe of *Tmesipteris* of the Psilotaceae (Ogura 1972).

The xylem consists of metaxylem and protoxylem. The pericycle is composed of single layer of large cells, which lies in the phloem. The phloem is composed of parenchyma and sieve cells. Stipe anatomical features were report to be suitable for the systematic study of fern because of the variations in shape of steles, the presence of sclerenchyma etc. (Ogura 1972; Bidin & Anita 1995; Bidin & Aryati Masturi 1996).

CONCLUSION

Problems in species identification in *Selaginella* due to the similarities in morphological characteristics could be solve using anatomical characteristics. Based on the stipe anatomical characteristics, the

Selaginella species studied were classifies into the monostelic and tristelic groups. The stele observed in all species studied is of the primitive protostelic type. The monostelic stelar type is in the form of dorsiventral protostele where the flat xylem is provide with protoxylems at both ends.

The stele shape and size of the upper part and the lower part of the stipes belong to the same species are found to be variable in some species. By combining the morphological and anatomical features of each species in this family, an identification key to species will make the identification process becomes easier with the more available data provided to distinguish each species in this family.

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Nurfarahain Zainal
Institute for Environment and Development (LESTARI)
UKM 43600 Bangi, Selangor
E-mail: ainzainal1588@yahoo.com

Haja Maideen Kader Maideen
School of Environmental & Natural Resource Sciences
Faculty of Science & Technology
UKM 43600 Bangi, Selangor
E-mail: deen@ukm.edu.my

Shaharuddin Mohamad Ismail
Institute for Environment and Development (LESTARI)
UKM 43600 Bangi, Selangor
E-mail: shahruddinmdi@gmail.com

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